Evaluation of Metered-Dose Inhaler Administration Technique among Asthmatic Children and Their Caregivers in Thailand

Jitladda Deerojanawong, Vimonmas Promsaka na Sakolnakorn, Nuanchan Prapphal, Chantana Hanrutakorn and Suchada Sritippayawan

SUMMARY Ninety-three asthmatic children and their caregivers were studied on their techniques of inhaler administration. Factors associated with the correct use of the device were also evaluated. Only 55.9% of the studied children demonstrated the correct technique in using their inhalation devices. In children using MDI (n = 42), the most common incorrect performance was the step of breathing in slowly at the same time with actuation (n = 17, 40.5%). Among those who used MDI-spacer (n = 51), all medication was given by their caregivers. The most common error was the step of waiting for 30 seconds prior to the next MDI actuation (n = 13, 25.5%). Factors related to the correct performance included duration of use for more than 1 year (p = 0.02), instruction of inhalation technique by trained technicians (p = 0.04) and the education level of the caregivers (p = 0.01). Our study demonstrates that incorrect technique during inhalation is common among Thai children with asthma and emphasizes an essential role of health professionals in regular evaluation of their patients and caregivers to ensure their correct application.

Asthma becomes one of the major public health burdens with increasing prevalence in most countries. The burden of the disease does not only affect the patients and their families but also the economy of the countries. According to the guidelines issued by the Global Initiative for Asthma (GINA), environmental control and medications are the two major components in asthma management.¹ As for medication, inhalation is the preferred route of administration in the management of asthma because drugs can be delivered directly into the airways, providing more rapid onset of action, allowing the administration of smaller doses of drugs and fewer systemic side effects.^{2,3} However, inhaled medication also has some disadvantages. One of the most common disadvantages is that specific inhalation technique is necessary for the proper use of each type of inhaler devices. A less than optimal technique can result in decreased drug delivery and thus potentially reduce its efficacy.⁴ Several devices have been used to deliver inhaled medication including metered-dose inhaler (MDI), dry powder inhaler (DPI), and nebulizer. Among these, MDI is the most common device being used in daily asthmatic management; it is portable, quicker to be used, and less expensive.³ However, there are many children unable

From the Department of Pediatrics, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand. Correspondence: Jitladda Deerojanawong

E-mail: jitladda.d@chula.ac.th, jitladda.d@gmail.com

to use MDI properly. Spacer is another device designed to improve the efficacy of inhalation technique, and it is usually prescribed for children who have difficulty in using MDI alone.⁵ Previous studies have shown that many asthmatic children and their parents are unable to perform proper inhalation techniques even after receiving instructions.⁶⁻¹² The correct use of the inhalation devices is essential for successful therapy. Therefore, several published reports including the GINA and National Institute of Health (NIH) guidelines emphasize the importance of comprehensive instructions provided at the time of prescription of the inhaled drugs as well as regular evaluations of inhalation technique during the follow up visits.^{1,8,9,13-16}

In this study, we evaluated the proper technique in using MDI, with or without spacer, among asthmatic children and their caregivers, as well as identified the skills that should be emphasized under close monitoring during their outpatient visits. In addition, factors associated with correct inhalation technique in these children and their caregivers were evaluated.

PATIENTS AND METHODS

A prospective descriptive study was performed on asthmatic children who attended the Outpatient Chest Clinic of Chulalongkorn University Hospital, a tertiary and teaching hospital, in Bangkok, Thailand. All children were diagnosed with asthma by a pediatric pulmonologist based on history, physical examination and spirometry (when feasible). They were prescribed inhaled asthmatic medications as appropriate for their age and asthma severity. All patients and/or their caregivers were instructed to use the proper inhalation technique by physicians (pediatric residents, general pediatricians) or trained technicians (in Outpatient Chest Clinic) before prescribing the medication.

From January 2004 to December 2004, patients who were using MDI or MDI with spacer and their caregivers were enrolled in the study. Data were collected during regular follow-up visits after written informed consent was obtained from the patients and their caregivers. The patients and/or their caregivers were asked to demonstrate (with a placebo) how they used the MDI or MDI with spacer at home. Their inhalation technique was evaluated by a trained technician and an investigator physician who recorded their findings on a standardized checklist.

Measures

The checklist was based on the recommendations of the National Institute of Health (NIH)¹³ and was reviewed by project staff for its applicability for children's uses of MDI and MDI-spacer. The MDI checklist contained 10 steps; 7 of which were considered essential for adequate drug delivery. As

 Table 1
 Steps required for proper MDI and MDI-spacer uses
MDI MDI-spacer 1. Shaking MDI and removing cap* 1. Shaking MDI and removing cap* 2. Breathe out slowly and fully* 2. Connect MDI to spacer* 3. Holding MDI upright 3. Holding MDI upright 4. Place MDI in mouth or 1-2 inches away from 4. Place mouthpiece between teeth and lips or place facemask over nose and mouth and form a seal* mouth* 5. Activation of the MDI only once* 5. Actuate the MDI once* 6. Begin to breathe in at the same time of actuation 6. Take 5-6 deep and slow breaths* and breathe in slowly' 7. Wait for at least 30 seconds before next actuation* 7. Hold breath for 10 seconds* Rinse the mouth after the use of a steroid inhaler 8. Take inhaler out of mouth and maintain mouth closina 9. Wait for at least 30 seconds before next actuation? 10. Rinse the mouth after the use of a steroid inhaler *Essential step

for MDI-spacer, 8 steps were scored; 6 of which were considered essential for adequate drug delivery (Table 1). The inhalation technique was considered correct when all essential steps were properly performed.

Patients' demographics, frequency of asthmatic attacks and data that might have an influence on inhalation performance were also recorded. These included education level of caregivers, duration of their current inhaler usage, the first instructor of inhalation technique as well as the frequency of receiving instructions.

Statistical analysis

All data were presented as number (percentage) or mean \pm SD as appropriate. Factors associated with the correct inhalation technique were analyzed using the Chi-square test and one way ANOVA. The *p*-value < 0.05 was considered statistically significant. All data were analyzed using SPSS for Windows.

RESULTS

Patients

During the study period, 93 patients and their caregivers were evaluated for their inhalation technique. The patient age ranged from 3 to 14 years with the mean age of 7 years. Fifty-nine patients (63.4%) were male and 34 (36.6%) were female. Sixty-six patients (71%) had asthmatic attack requiring extra MDI usage less than once per week and all patients used their extra MDI for asthmatic attack less than 3 times a week. Forty-two children used MDI alone (MDI group) and 51 children used MDI with spacer (MDI-spacer group). These two groups underwent separate analysis since they were in different age groups and their inhalation techniques were different.

Evaluation of inhalation technique

Of the 93 children and caregivers, 52 (55.9%) performed all the essential steps correctly. The percentage of the children and caregivers who demonstrated the correct technique was 50.0% in the MDI group and 60.8% in the MDI-spacer group.

In children using MDI alone, the mean age \pm SD was 10.1 \pm 2.6 years. Thirty-one (73.8%) children used MDI by themselves and 11 (26.2%) always used MDI under their caregivers' supervision. The mean duration \pm SD of current inhaler usage was 33.8 \pm 18.2 months. The inhalation technique was first given by a physician in 26 (61.9%) patients. The rest were instructed by a trained technician. During evaluation, 15 (25.7%) children performed all the 10 steps correctly. Among the essential 7 steps of MDI inhalation technique, the most common incor-



rect performance was the step of breathing in slowly at the same time of actuation (n = 17, 40.5%). The percentage of correct performance in each step is shown in Fig. 1. Children over 10 years old were found to have significantly higher percentage of correct performance in all essential steps (p = 0.02). However, use of inhaler by themselves or under their parents' supervision, physicians as the first instructors of inhalation technique, and frequency of receiving instructions were not significantly associated with the correct performance (Table 2).

90

The mean age \pm SD of children who used MDI-spacer was 5 ± 3.4 years old. All subjects were given medication by their caregivers (usually mother). The mean duration \pm SD of current inhaler

usage was 24.1 ± 2 months. Thirty (55.9%) patients were first given an instruction of inhalation technique by a physician. The rest were instructed by a trained technician. Twenty-four (47.1%) caregivers demonstrated the correct performance in all the 8 steps in using the device. Among the essential 6 steps of MDI-spacer inhalation technique, the most common error made by the caregivers was the step of waiting for 30 seconds prior to the next MDI actuation (n = 13, 25.5%). The percentage of correct performance in each step is shown in Fig. 2. The factors associated with correct inhalation technique in children using MDI-spacer included duration of inhaler usage for more than 1 year (p = 0.02), receiving an instruction of inhalation technique by a trained technician in the chest clinic (p = 0.04), and



(*essential step).

the education level of the caregivers (p = 0.01)(Table 3). Further analysis by one way ANOVA demonstrated that a significantly higher number of caregivers who graduated from high school (p = 0.02) or university (p = 0.00) had correct performance in administering the device when compared to the caregivers who graduated from preliminary school. However, there was no significant difference between the caregivers who graduated from university in performing correct inhalation technique.

DISCUSSION

Our study shows that only 55.9% of asthmatic children who attended the Outpatient Chest Clinic were able to use their inhalers correctly. Among children who used MDI, only 50% could properly perform all the essential inhalation steps. The most common error found in this study was the step of breathing in slowly at the same time of actuation similar to the finding in the study of Chen et al. and Giraud et al.^{8,13} To perform this step, the patient should have hand-breath coordination and breathe in slowly. If there is a delay between actuation and inhalation or if the patient inhales too rapidly, the delivery of the medication into the airways would be affected.^{14,17} It has been reported that actuation of one second prior to inhalation reduces inhaled mass by 90%.¹⁸ Similarly, a late actuation in the inspiration cycle may fill the anatomical dead space with aerosol, which is then exhaled before it can enter the targeted airways.¹⁴ There were some studies reporting that the most common error of MDI usage was failure to shake the inhaler before use.^{6,7,11} This step is necessary for homogenous mixing of the various ingredients in the canister prior to refilling the metering chamber.¹⁴ Surprisingly, all children in our study performed this step correctly. This may be explained by the easy performance of this step and our emphasize on this step during teaching.

For children who used MDI with spacer, the performance of the caregivers was better than that of the MDI group. This could be explained by the fact that MDI-spacer is easier to use as a spacer does not need breath-holding period and there is no effect of hand-breath incoordination. In fact, the step of breath-holding is also recommended for MDI-spacer in NIH guideline. Since there were studies demonstrating that this step was not necessary in young children, it was not considered as a step required for proper MDI-spacer use.^{7,19,20} The most common error in this group was the step of waiting for 30 seconds between inhalations and the step of single actuation prior to inhalation. Studies in the past demonstrated that a single MDI actuation followed by an inhalation delivered the greatest amount of drugs per actuation when compared to multiple actuations.^{21, 22} Therefore this step should be given more attention for proper use of this device.

The only factor that was significantly related to the correct MDI technique in this study was the

	Correct (n = 31) (n, %)	Incorrect (n = 20) (n, %)	<i>p</i> -value
Duration of use > 1 year	25 (80.7%)	10 (50.0%)	0.02
First instruction by trained technicians	18 (58.1%)	4 (20.0%)	0.04
Frequency of instructions			NS
- Once	10 (32.3%)	10 (50.0%)	
- Twice	11 (35.5%)	3 (15.0%)	
- More than twice	10 (32.3%)	7 (35.0%)	
Caregiver education			0.01
- Preliminary	6 (19.4%)	14 (70.0%)	
- High school	12 (38.7%)	5 (25.0%)	
- University	13 (41.9%)	1 (5.0%)	

age of the patient. This finding was comparable to the studies which demonstrated that age was one of the significant factors for the correct use of the device.^{7,9} Although the National Asthma Guidelines recommended the use of MDI in children over the age of 6 years, our study showed that the correct use was significantly higher in children over 10 years old. As for the children who used MDI-spacer, we found that factors associated with correct inhalation technique included the education level of the caregivers, the duration of the device usage (> 12 months) and having a trained technician as the first instructor. The duration of device usage and the education level of the caregivers have been reported as significant factors related to the correct technique.^{7, 8} However, some studies demonstrated different results.^{9,11} The only factor that was significantly related to the correct technique recommended in several studies was the repeated inhalation instructions.^{1,13-15} In this study, we did not find any correlation of correct inhalation technique and the frequency of being instructed in both groups. This could be explained by the fact that we usually spent more time giving education or reevaluating the inhalation technique in children with poorly controlled asthma than the majority of asthmatic children who were in good control. This bias selection in giving repeated instructions only in a special group of patients may be the cause

The population in our study was children who attended the chest clinic regularly and most of their asthmatic symptoms were controlled. The selection bias in recruiting patients, if any, might increase the number of individuals who used the correct technique than that would be expected in the general population. Nevertheless, the result showing that nearly half of our patients performed inhalation technique incorrectly suggested that more attention should be given to patients' inhalation technique. The use of the inhaler device should be evaluated (and corrected if necessary) regularly and repeatedly in every follow-up visit.

of these different findings.

In conclusion, poor inhalation technique in asthmatic children is still common. MDI with spacer appeared to be an easier device to use than MDI alone. It remains important to evaluate each individual's inhalation technique regularly and repeatedly to ensure reliable inhalation technique in asthmatic children.

REFERENCES

- 1. Global Initiative for Asthma. Global strategy for asthma management and prevention. Available from: http://www.ginasthma.org (accessed on 20 April 2007).
- Everard ML. Aerosol delivery to children. Pediatr Ann 2006; 35: 630-6.
- 3. Pongracic JA. Asthma medications and how to use them. Curr Opin Pulm Med 2000; 6: 55-8.
- Dolovich MB, Ahrens RC, Hess DR, et al. Device selection and outcomes of aerosol therapy: evidence-based guidelines: American College of Chest Physicians/American College of Asthma, Allergy, and Immunology. Chest 2005; 127: 335-71.
- Child F, Davies S, Clayton S, Fryer AA, Lenney W. Inhaler devices for asthma: do we follow the guidelines? Arch Dis Child 2002; 86: 176-9.
- Vella C, Grech V. Assessment of use of spacer devices for inhaled drug delivery to asthmatic children. Pediatr Allergy Immunol 2005; 16: 258-61.
- Walia M, Paul L, Satyavani A, Lodha R, Kalaivani M, Kabra SK. Assessment of inhalation technique and determinants of incorrect performance among children with asthma. Pediatr Pulmonol 2006; 41: 1082-7.
- Chen SH, Yin TJ, Huang JL. An exploration of the skills needed for inhalation therapy in schoolchildren with asthma in Taiwan. Ann Allergy Asthma Immunol 2002; 89: 311-5.
- Scarfone RJ, Capraro GA, Zorc JJ, Zhao H. Demonstrated use of metered-dose inhalers and peak flow meters by children and adolescents with acute asthma exacerbations. Arch Pediatr Adolesc Med 2002; 156: 378-83.
- Kamps AW, van Ewijk B, Roorda RJ, Brand PL. Poor inhalation technique, even after inhalation instructions, in children with asthma. Pediatr Pulmonol 2000; 29: 39-42.
- Kamps AW, Brand PL, Roorda RJ. Determinants of correct inhalation technique in children attending a hospital-based asthma clinic. Acta Paediatr 2002; 91: 159-63.
- Burkhart PV, Rayens MK, Bowman RK. An evaluation of children's metered-dose inhaler technique for asthma medications. Nurs Clin North Am 2005; 40: 167-82.
- National Asthma Education and Preventation Programme, Expert panel report 2. Guidelines for the diagnosis and management of asthma: NIH Publication No. 97-4051: 1997.
- Fink JB, Rubin BK. Problems with inhaler use: a call for improved clinician and patient education. Respir Care 2005; 50: 1360-74; discussion 1374-5.
- 15. Minai BA, Martin JE, Cohn RC. Results of a physician and respiratory therapist collaborative effort to improve longterm metered-dose inhaler technique in a pediatric asthma clinic. Respir Care 2004; 49: 600-5.
- Numata Y, Bourbeau J, Ernst P, Duquette G, Schwartzman K. Teaching time for metered-dose inhalers in the emergency setting. Chest 2002; 122: 498-504.
- Geller DE. Comparing clinical features of the nebulizer, metered-dose inhaler, and dry powder inhaler. Respir Care 2005; 50: 1313-21; discussion 1321-2.
- Wilkes W, Fink J, Dhand R. Selecting an accessory device with a metered-dose inhaler: variable influence of accessory devices on fine particle dose, throat deposition, and drug delivery with asynchronous actuation from a metered-dose inhaler. J Aerosol Med 2001; 14: 351-60.

- 19. James RW, Masters IB. Single breath *versus* panting technique in salbutamol delivery through a 750 ml spacing device. Pediatr Pulmonol 1990; 8: 263–7.
- 20. Hansen OR, Pedersen S. Optimal inhalation technique with terbutaline Turbuhaler. Eur Respir J 1989; 2: 637–9.
- 21. Barry PW, O'Callaghan C. Multiple actuations of salbutamol MDI into a spacer device reduce the amount of drug recovered in the respirable range. Eur Respir J 1994; 7: 1707-9.
- Rau JL, Restrepo RD, Deshpande V. Inhalation of single vs multiple metered-dose bronchodilator actuations from reservoir devices. An *in vitro* study. Chest 1996; 109: 969-74.